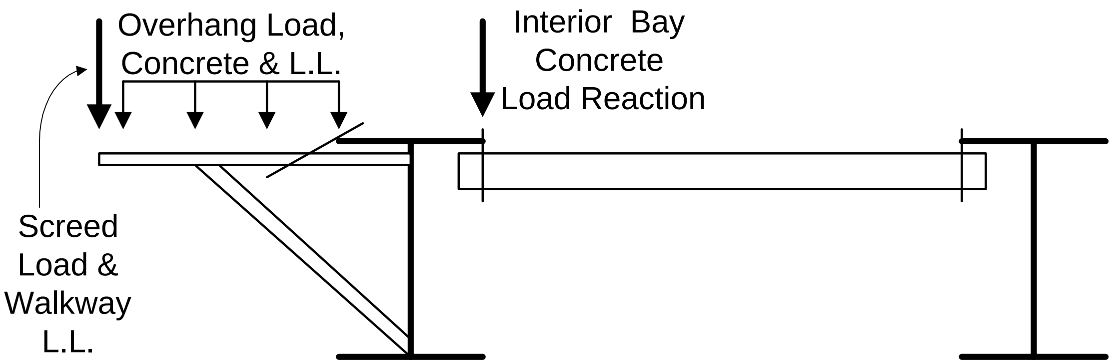
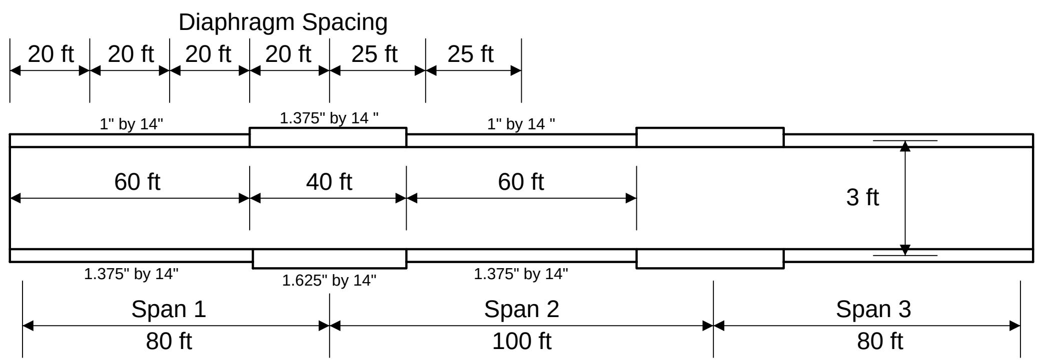
LATERAL GIRDER ROTATION

Example:



Assume a three span welded plate girder bridge with overhangs of 3.25 ft and a deck thickness of 8 inches. The spans are 80 ft –100 ft – 80 ft. The distance between the centers of the top and bottom flange is approximately 3.0 ft. The diaphragms are bent plates spaced at 20 ft in spans one and three and 25 ft in span two. The Girder spacings are 9.5 ft. The flanges vary as follows:



The top and bottom flanges actually act as twelve continuous sections for lateral load, however the remote sections have very little effect on deflections. Only two sections behind and one section in front of the section being checked need to be considered in the structural model, this limits the analysis to no more than four sections (see case 1 and 2 in this example).

There are four vertical loads that should to be considered for the rotational effects:

1. The deck overhang concrete load.
2. The deck interior bay concrete load reaction on the exterior girder.
3. The screed load on the overhang.
4. The construction live load and walkway load in the work zone.
   (The work zone is considered to be a 20 ft. long zone centered on the screed)

It is not necessary to consider the weight of the falsework because it is already in place when the form grades and screed rail settings are made.

In this example the deck weighs 100 lbs/ft^2, however an assumption must be made for the screed load. In this example the screed is assumed to weigh 4500 lbs per side spread out over 10 ft. The construction live load is 30 lbs/ft^2 and the walkway load is 75 lbs/ft.

The load per foot of length with associated moment arms, the resulting torsion and the equivalent lateral load applied to the flanges are as follows:

Deck Overhang – Load = 100(3.25 – (1.16/2)) = 267 lbs/ft (overhang minus half the flange width)
MomArm = (3.25 – (1.16/2))/2 + 1.16/2 = 1.92 ft
Torsion = 267(1.92) = 513 lbs*ft/ft
Lateral Load = 513/3 = 171 lbs/ft

Interior Deck – Load = 100{(9.5 – 1.16)/2} = 417 lbs/ft (girder spacing minus flange width divided by 2)
MomArm = 1.16/2 = 0.58 ft (one half the flange width)
Torsion = 417(0.58) = 242 lbs*ft/ft
Lateral Load = 242/3 = 81 lbs/ft

Total Lateral Concrete Loads = 171 – 81 = <u>90 lbs/ft</u> (applied to all sections behind and including the one being checked)

Screed Load – Load = 4500/10 = 450 lbs/ft
MomArm = 3.25 ft
Torsion = 450(3.25) = 1463 lbs*ft/ft

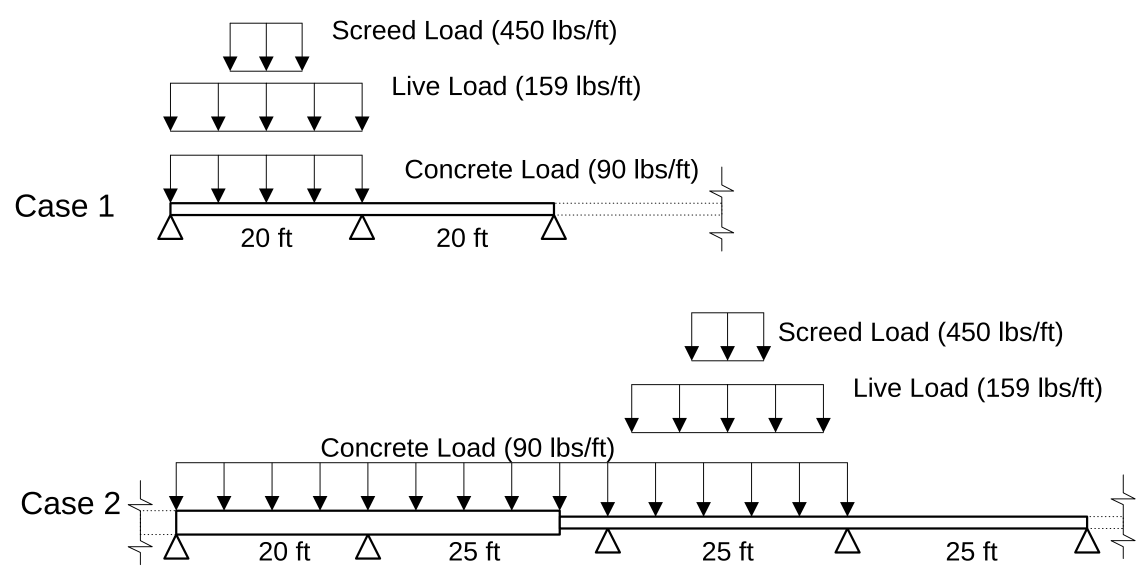
Screed Lateral Load = 1463/3 = <u>488 lbs/ft</u> (only applied to 10 ft at center of section checked)

Uniform L.L. – Load = 30(3.25) = 98 lbs/ft (only applied to overhang area, a conservative assumption)
MomArm = (3.25)/2 = 1.63 ft
Torsion = 98(1.63) = 160 lbs*ft/ft
Lateral Load = 160/3 = 53 lbs/ft

Walkway L.L. – Load = 75 lbs/ft
MomArm = 3.25+1 = 4.25 (applied one foot beyond edge of deck)
Torsion = 75(4.25) = 319 lbs/ft
Lateral Load = 319/3 = 106 lbs/ft

Total Lateral L.L. = 53 + 106 = <u>159 lbs/ft</u> (only applied to 20 ft at center of section checked)

The top flange has a moment of inertia of 229 in^4 or 314 in^4, depending on flange thickness. The bottom flange has a moment of inertia of 314 in^4 or 372 in^4. The deflection in this example is checked at two places, halfway between the abutment and first diaphragm (Case 1) and halfway between the fifth and sixth diaphragm, which is near the center of the second span (Case 2). The girder is assumed to be progressively loaded as the deck is placed with the screed located at the center of the last section to be loaded. For analysis purposes only one unloaded section and at most two loaded sections, other than the section being checked, need to be included when calculating the deflections. This is a conservative simplification; actual deflections will be slightly less.



Case 1: Deflection at midspan of the first section in the case 1 model:

Concrete Load Deflection Top Flange = 0.035 in
Screed Load Deflection Top Flange = 0.124 in
Live Load Deflection Top Flange = 0.061 in

Concrete Load Deflection Bottom Flange = 0.025 in
Screed Load Deflection Bottom Flange = 0.090 in
Live Load Deflection Bottom Flange = 0.044 in

Rotation = (0.035 + 0.124 + 0.061 + 0.025 +0.090 + 0.044)/36 = 0.0105 radians

Deflection at end of overhang = 0.0105(3.25)(12) = 0.41 in > 0.20 *Deflection is too great.*

Case 2: Deflection at midspan of the third section of the case 2 model:

Concrete Load Deflection Top Flange = 0.043 in
Screed Load Deflection Top Flange = 0.182 in
Live Load Deflection Top Flange = 0.100 in

Concrete Load Deflection Bottom Flange = 0.031 in
Screed Load Deflection Bottom Flange = 0.134 in
Live Load Deflection Bottom Flange = 0.074 in

Rotation = (0.043 + 0.182 + 0.100 + 0.031 + 0.134 + 0.074)/36 = 0.0157 radians

Deflection at end of overhang = 0.0157(3.25)(12) = 0.61 in > 0.20 *Deflection is also too great, either the diaphragm spacing will need to be reduced or a smaller overhang used.*

Once the deflections are satisfactory the diaphragm and its connection to the girder should be checked:

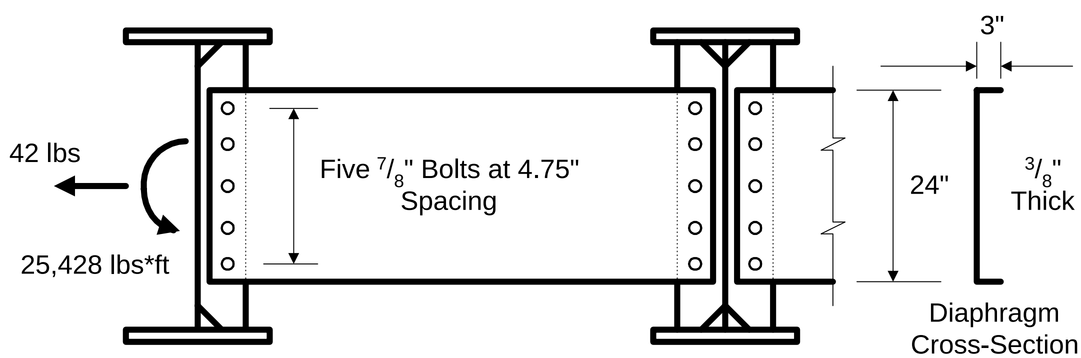
The greatest reaction at a diaphragm is in Case 2 just to the left of the section that has the screed load applied to it. The reaction loads at this diaphragm are as follows:

Top Flange Reaction– Concrete Load = 2400 lbs
Screed Load = 2790 lbs
Live Load = 1900 lbs

Bottom Flange Reaction– Concrete Load = 2410 lbs
Screed Load = 2760 lbs
Live Load = 1890 lbs

Assuming the diaphragm is centered on the girder web the net "LRFD Service II" slip critical moment and force on the bolt pattern is,

Net factored moment = (3/2){1.0(2400 + 2410) + 1.3(2790 + 1900 + 2760 + 1890)} = 25,428 lbs*ft
Net factored force = 1.0(2400 – 2410) + 1.3(2790 + 1900 – 2760 – 1890) = 42 lbs



The bolt pattern has a moment of inertia of 226 in^2 therefore the maximum bolt shear is:

25,428(12)(9.5)/226 + 42/5 = 12835 lbs

The nominal resistance of a $^7/_8$", A325 bolt for a standard hole with a Class A surface (Art. 6.13.2.8):

$K_h K_s N_s P_t$ = 1.0(0.33)(1.0)(39) = 12.87 kips 12.835 kips < 12.87 kips *OK*

The diaphragm has a section modulus of 63 in^3 and therefore the factored bending moment in the diaphragm and the associated stress for "Strength I":

Factored moment = (3/2){1.25(2400 + 2410) + 1.75(2790 + 1900 + 2760 + 1890)} = 33,536 lb*ft
Factored stress = 33,536(12)/63 = 6388 lbs/in^2

The factored resistance is based on a stress equal to the yield stress of 50 ksi.

6.388 ksi < 50 ksi *OK*

*** Revision of 11/2003 added uniform live load and walkway live load to overhang.**